ANALYSIS OF THE DIELECTRIC PROPERTIES AND THE CHARGE TRANSFER MECHANISMS OF HYBRID ORGANIC-INORGANIC PROTON EXCHANGE MEMBRANES BASED ON SULFONATED STYRENE-ETHYLENE-BUTYLENE-STYRENE

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Sulfonated styrene–ethylene–butylene–styrene (sSEBS) membranes have gained significant interest as promising electrolytes for fuel cells due to their reduced cost and high proton conductivity. In addition, they merge the elasticity typical of elastomers with the ease of processing characteristic of thermoplastic materials [1-3].

A series of sSEBS block copolymer membranes was prepared by blending sSEBS solutions with varying weight percentages (10, 20, 30, and 40 wt%) of an organic–inorganic hybrid compound (MG), which acts as a coupling agent to produce a hybrid material. The MG is formulated with a 70/30 ratio of two silane monomers, 3-mercaptopropyltrimethoxysilane (MPTMS) and 3-glycidoxypropyltrimethoxysilane (GPTMS) [4]. The prepared membranes were subsequently analyzed to achieve a more comprehensive understanding of their thermal behavior, molecular dynamics, as well as their electrical and proton conductivity properties.

FTIR analysis confirmed that incorporation of the hybrid precursor altered the sSEBS structure by increasing the number of Si-O-Si linkages, thereby generating stable proton-conducting pathways. DSC measurements further demonstrated the MG hybrid precursor's hydrophilic character, resulting in a decrease in the glass transition temperature. Dielectric Spectroscopy identified four distinct relaxation processes associated with the EB and PS segments. Overall, the findings suggest that incorporating MG facilitated the introduction of sulfonic acid groups through oxidation of thiol functionalities, produced a plasticizing effect, and consequently improved proton transport while lowering electrical conductivity. Nevertheless, high MG contents were shown to adversely influence molecular dynamics by diminishing free volume, ultimately resulting in decreased proton conductivity.

Among the membranes evaluated, those incorporating 10–20 % of the MG hybrid precursor displayed the most advantageous compromise between structural and functional characteristics. This proportion improved thermal stability without compromising structural integrity and achieved enhanced proton conductivity alongside reduced electrical conductivity. Overall, the results highlight the need for carefully controlled hybrid precursor content to achieve an optimal balance between structural modification and performance, reinforcing the potential of these materials for proton exchange membrane fuel cell (PEMFC) applications.

References

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